GAPSS
(GRAPHICAL ANALYSIS PROCEDURES FOR SYSTEM SIMULATION)

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ABSTRACT

~~This~~ paper discusses two types of computer graphics displays used to analyze data following simulation runs. The display showing values over time was superior to the display sequentially presenting individual states of a system.

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I. INTRODUCTION

The RAND Corporation is developing Graphical Analysis Procedures for System Simulation primarily to learn how computer graphics can aid people in their analysis of simulated systems. This paper reports interim progress on graphically displaying the results of simulations done in the GPSS language.

The first step of our procedure has been to run a simulation and store period-by-period results on disk. As a separate step we analyze the results graphically. This allows us to view the data in many ways without waiting for repeat simulations.

A simple simulation of a Health Center will illustrate the graphical analysis procedures. The usual stream of sick

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patients are entering it, with additional emergency patients coming through an emergency entrance. Only one doctor will be observed in detail although a number are there. The doctor uses two examining rooms; a patient is examined in one room while the other room is cleaned. Patients wait in the waiting room if all examining rooms are full.

After this simulation had been run and the data stored on disk, it was graphically analyzed using procedures implemented on the IBM 360/40, the IBM 2250 graphical display unit, and the RAND Tablet (shown in Fig. 1). The RAND Tablet receives all human control input. The position of the pen appears on the screen when the operator writes on the tablet. To control the display, one prints characters on the RAND Tablet that are recognized by software and replaced by standard characters.

Fig. 1—Graphic display station

II. DISPLAY SEQUENTIALLY PRESENTING INDIVIDUAL STATES OF SYSTEMS

The first display (Fig. 2) shows the state of four system variables at any one point in simulated time. In this case the person has requested information about a Facility (F41, which represents the doctor) by printing an F for the TYPE and 41 for the NUMBER in the upper-left graph. The bottom graphs give the states of the two examining rooms. The upper-right graph reports the length of the queue (Q21) of patients waiting for an examining room. If a Facility is idle, its value is zero; if in normal use, one; if in emergency use, two. Each graph has a scaling factor printed in giving the ratio of the displayed value to the actual value. The "graphs" are essentially vertical bar charts with heights indicating the absolute magnitude of the variable. The remainder of the scaled value after division by 10 is indicated on the horizontal scale.

The relative clock time appears at the top of the display. In Fig. 2 the relative clock time happens to be 9009. Time can be moved backward or forward one state at a time by pressing the pen in the ONE ONLY box or continuously moved at various speeds by pressing in the FASTER box.

Unfortunately, people have great difficulty using this display. The operator must remember past data to detect changes--and changes are usually very important. Because human memory is inadequate for the task, much of system performance remains undetected and many of the simulated system's characteristics seem hidden, so we tried another method.

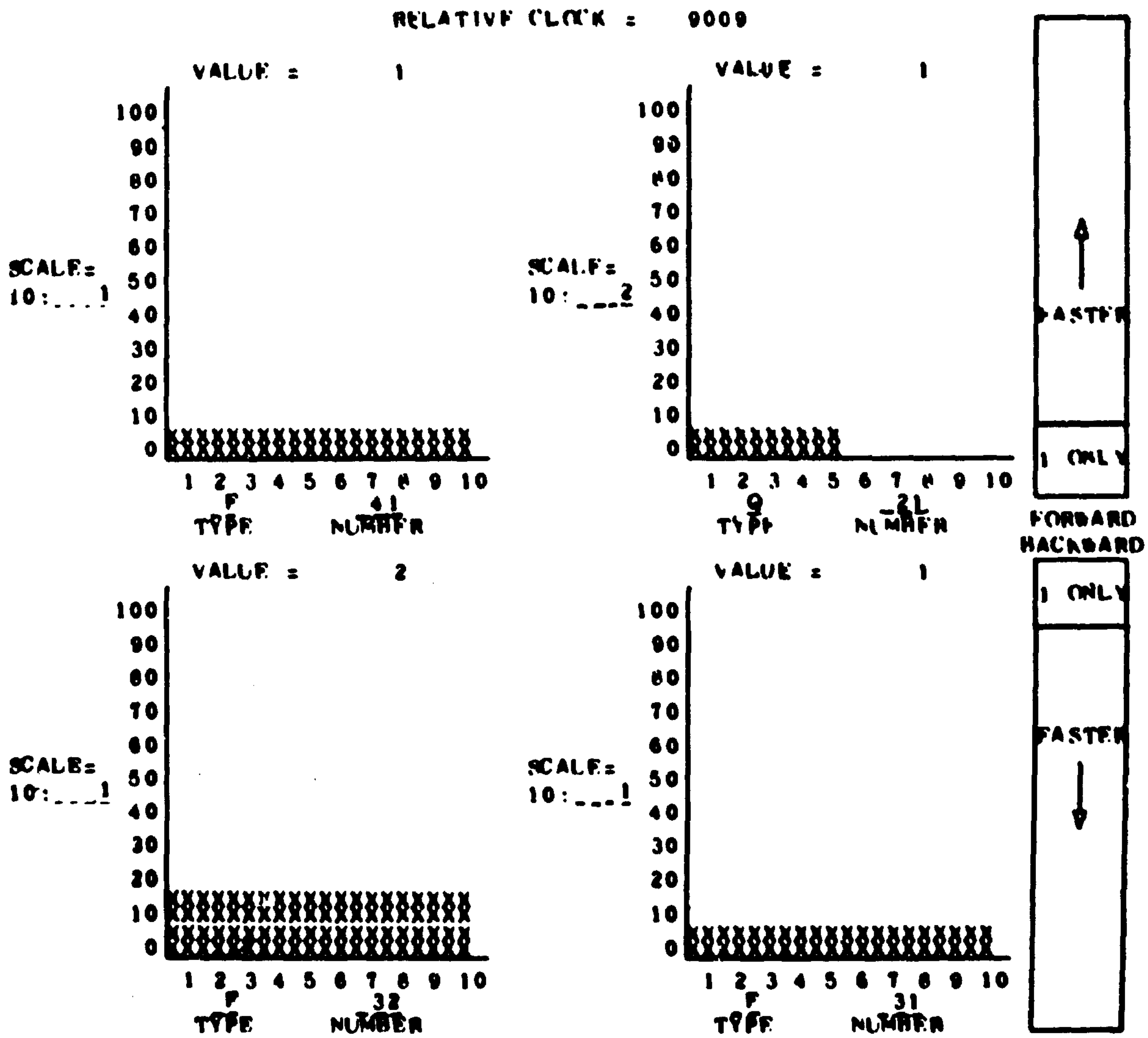

Fig. 2—Display sequentially showing individual states of system

III. HYBRID DISPLAY SHOWING CHANGES OVER TIME

The new display is a hybrid (see Fig. 3). At the bottom is a Gantt chart, named for its creator, Henry Gantt. At the top is a simple graph of a variable over time. The operator changes the limits of time to be displayed by printing them on the RAND Tablet. In Fig. 3 the limits have been set to start 1½ hours into the day and end 2 hours later. A second is the smallest time increment in the system, so the limits are 5400 and 12,600 seconds.

On the top portion Q21 is examined. Ten is the maximum value and zero is the minimum. Time is the independent variable with queue length plotted vertically. This graph presents the same data as the previous display, but profiles use over time.

Which patient is using which facility is presented on the lower part of the display in the Gantt chart. The chart indicates the time a patient is using the facility by a bar with the patient number above it. For example, the bottom of the chart gives information about the emergency entrance, Facility 2. Patient 28 has passed through the emergency entrance rapidly, entering at about time 8000. Changing the time limits of the display to magnify the relevant period enables a more detailed examination of this emergency case. Therefore, in Fig. 4 the time limits are 7500 and 10,500 seconds.

The top portion of the display now shows the doctor's state-idle (0), in normal use (1), or in emergency use (2). The doctor begins treating an emergency when the value of F41 goes from one to two. Looking down to the Gantt chart,

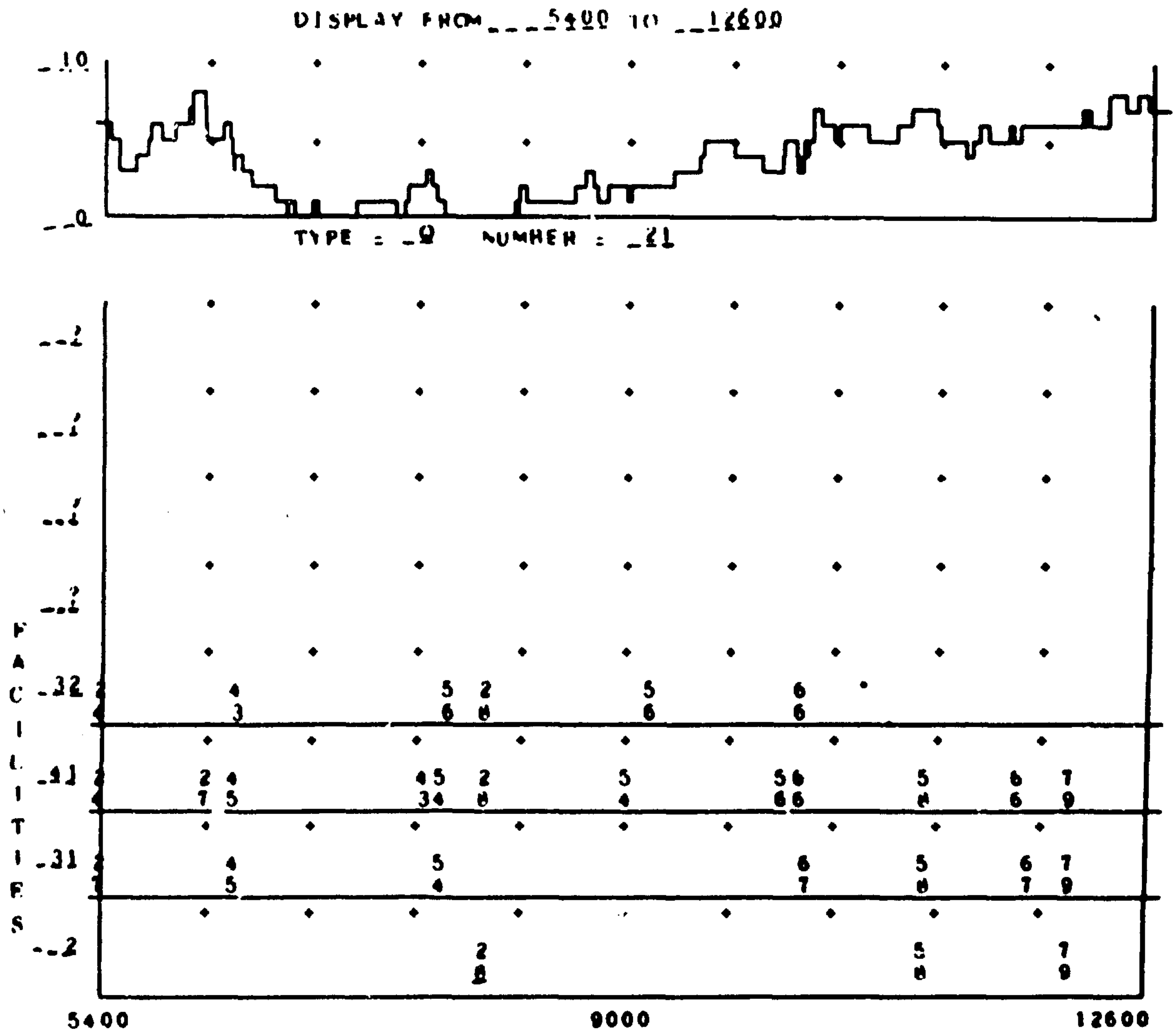

Fig. 3—Hybrid display, broad time limits

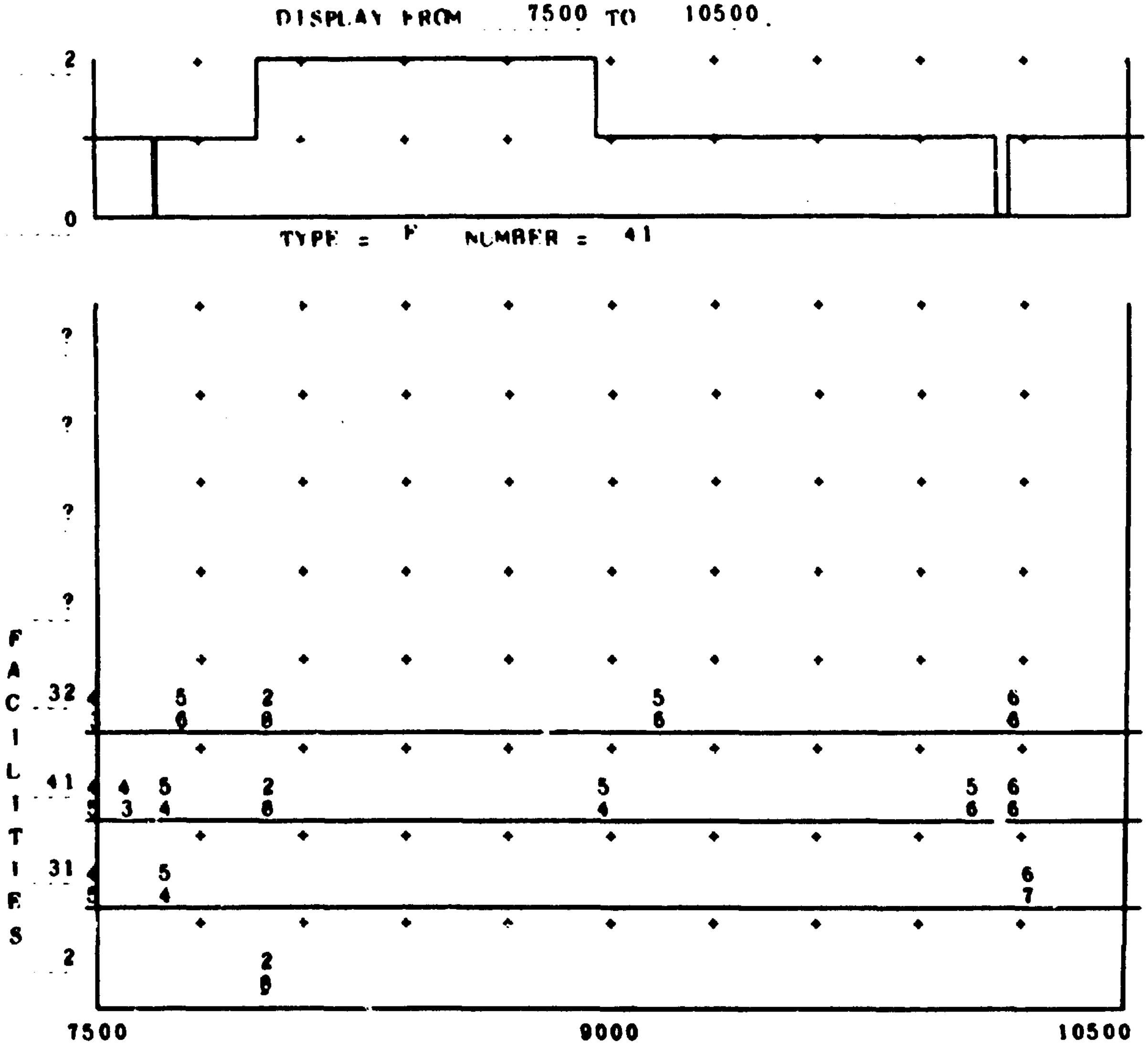

Fig. 4—Hybrid display, narrow time limits

Patient 28 is the emergency. With the narrowed time limits, we can easily examine in detail this patient's progress through the system.

IV. CONCLUSIONS

A study to test usefulness confirmed the observation that the two display types differ greatly in power. The study contributed to knowledge about the usefulness of the two, as well as teaching more general lessons. Four of the most important points are:

1. An analyst almost never views simulation data the right way on the first try.
2. Computer graphics helps an analyst identify relationships obscured by summary statistics.
3. The first display (Fig. 2) is less useful than the second display (Figs. 3 and 4) in solving simulation problems.
4. Computer graphics displays should be tested for usefulness by the people for whom they are designed; intuitive feelings are often wrong.

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